

AD-A093 318

CLAPP (WILLIAM F) INC DUXBURY MA

F/G 8/1

THE ACTIVITY OF LIMNORIA TRIPUNCTATA IN PILING CUT-OFFS FROM NA--ETC(U)

DEC 80 C I BELMORE

N00014-79-C-0667

NL

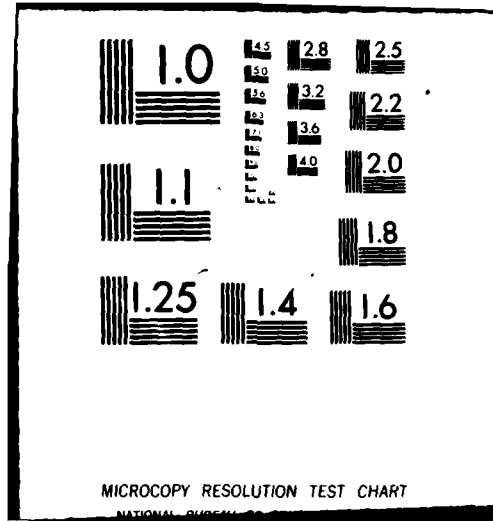
UNCLASSIFIED

15021

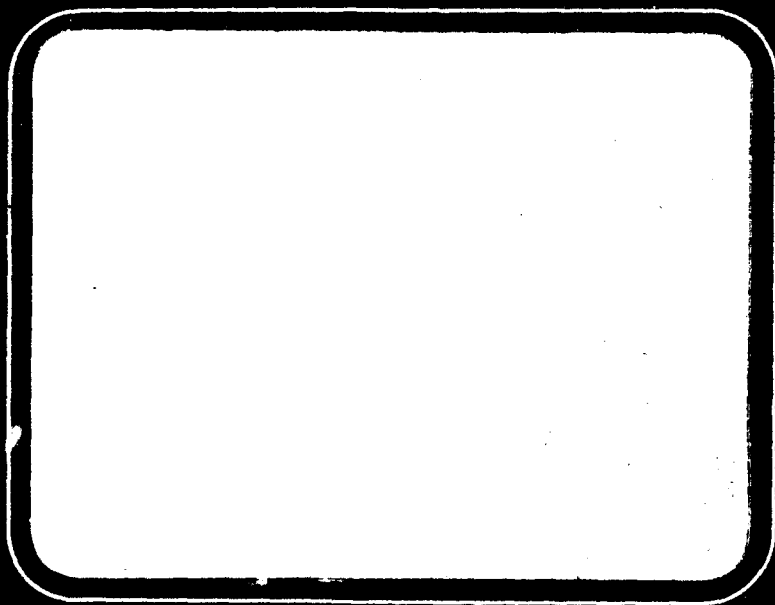
1-1
AD-A093 318



END
DATE
FILMED
2-81
DTIC



AD A093318



U.S. FILM CORP.

80 12 21 01

(12)

ANNUAL REPORT

on

THE ACTIVITY OF *Limnoria tripunctata*
IN PILING CUT-OFFS FROM
NAPHTHALENE-ENRICHED CREOSOTED PILINGS

to

UNITED STATES DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
MICROBIOLOGY BRANCH
CONTRACTS #N00014-79-C-0667
TASK NO. NR 205-034

December 19, 1980

by

C.I. Belmore

Report No. 15021

BATTELLE
New England Marine Facility
The William F. Clapp Laboratories
Duxbury, Massachusetts 02332

DEC 29 1980
C

Reproduction in whole or in part is permitted for any purpose of the United States Government. This document has been approved for public release; its distribution is unlimited.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

11/19 D 80

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NR 205-034	2. GOVT ACCESSION NO. AD-A093 318	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) The Activity of <u>Limnoria tripunctata</u> in Piling Cut-offs from Naphthalene-enriched Creosoted Pilings.		5. TYPE OF REPORT & PERIOD COVERED Annual 8/1/79-11/1/80
		6. PERFORMING ORG. REPORT NUMBER (14) 15021
7. AUTHOR(s) (10) C. Irene Belmore		8. CONTRACT OR GRANT NUMBER(s) (15) N00014-79-C-0667
9. PERFORMING ORGANIZATION NAME AND ADDRESS Battelle New England Marine Facility The William F. Clapp Laboratories		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 124126 NR 205-034
11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research Microbiology Branch - Code 443 800 N. Quincy Street Arlington, Virginia 22217		12. REPORT DATE 12/19/80
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Annual rep. 1 Aug 79- 1 Nov 80		13. NUMBER OF PAGES 18 (12) 27
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for Public Release; Distribution Unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) <u>Limnoria tripunctata</u> Piling Cut-offs Naphthalene-enriched Creosote Pholadidae		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Cut-offs from piling treated with creosote plus additional naphthalene at four levels were exposed to <u>Limnoria tripunctata</u> both in the laboratory and in the field. After one year of exposure, laboratory exposures indicate 10% and 20% additives to be more resistant to borer attack than the 30% and 40% additive samples. Field studies showed the 30% additive provided the best protection. The molluscan borer Pholadidae entered all discs exposed under field conditions		

DD FORM 1473
1 JAN 73

EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Copy 650

JAB

TABLE OF CONTENTS

	<u>Page</u>
MANAGEMENT SUMMARY.....	<i>i</i>
INTRODUCTION.....	1
OBJECTIVES.....	1
MATERIALS AND METHODS.....	2
Laboratory Exposures.....	2
Field Exposures.....	2
RESULTS AND DISCUSSION.....	3
Series 1 - Laboratory Exposures.....	3
Series 2 - Laboratory Exposures.....	8
Series 1 - Field Exposures.....	8
Series 2 - Field Exposures.....	12
Comparison of Field and Laboratory Exposures.....	14
Uncoated Wedges.....	14
Water Temperature.....	16

LIST OF TABLES

Table 1.	Order of Disc Placement on Rod, for Field Exposures of Daytona Beach, Florida.....	4
Table 2.	Number of <i>Limnoria</i> Tunnels in Wedges on Laboratory Exposure - Series 1.....	5
Table 3.	Mean Number of <i>Limnoria</i> Tunnels in Laboratory Wedges After 5 to 12 Months of Exposure.....	7
Table 4.	Area of Surface Exposed to <i>Limnoria tripunctata</i> of Series 1 Coated Wedges in Square Centimeters.....	9
Table 5.	Number of <i>Limnoria</i> Tunnels in Wedges on Laboratory Exposure - Series 2.....	10

LIST OF TABLES
(continued)

	<u>Page</u>
Table 6. Number of <i>Linnoria</i> Tunnels in Discs on Field Exposure.....	11
Table 7. Number of Specimens on Pholadidae in Discs on Field Exposure.....	13
Table 8. Mean Number of Marine Borers in Discs and Reconstituted Discs.....	15
Table 9. Laboratory Water Temperatures °C From November, 1979 Through October, 1980.....	17
Table 10. Daytona Beach Water Temperatures °C From September, 1979 Through September, 1980.....	18

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	

MANAGEMENT SUMMARY

Cut-offs from piling treated with creosote plus additional naphthalene at four levels were exposed to *Limmoria tripunctata* both in the laboratory and in the field.

After one year of exposure to active *Limmoria* attack in the laboratory, the coated wedges from the 10 percent naphthalene additive showed the greatest resistance to attack by *Limmoria tripunctata*.

The treatment which showed the least resistance to *Limmoria tripunctata* under laboratory conditions was the 30 percent additive.

In Series 1, which has had one year of exposure, the 30 percent naphthalene creosote discs showed the best resistance to *Limmoria* attack under field conditions and the 20 percent additive discs were most severely attacked. The 30 percent additive discs which were submerged for six months showed a heavier *Limmoria* attack than any of the discs exposed for 12 months.

Fouling organisms, especially barnacles were very heavy on all the discs exposed under field conditions.

During the September, 1980 inspection, molluscan borers (*Pholadidae*) were found in all treatments exposed at Daytona Beach, Florida. No significant variations were observed among the four treatments.

After one year of exposure to *Limmoria tripunctata* attack, both in the field and in the laboratory, the piling cut-offs with four different percentages of naphthalene plus creosote are all showing susceptibility to *Limmoria* attack. A longer exposure period should ascertain whether the initial trends will continue at the same rate.

THE ACTIVITY OF *Limmoria tripunctata* IN PILING CUT-OFFS
FROM NAPHTHALENE-ENRICHED CREOSOTED PILINGS

by

C.I. Belmore

INTRODUCTION

The need for an improved treatment for marine pilings has been recognized by both the United States Navy and industry. A satisfactory improved treatment must result in piling that will effectively prevent marine borer attack, resist breakage in handling and driving, and be economically feasible. Creosote-impregnated piling satisfies these needs except in areas where the wood-boring crustacean, *Limmoria tripunctata* exists, since *L. tripunctata* is relatively resistant to creosote.

Much has been accomplished in recent years towards improvement of treatments and development of new preservatives against borers and other destructive elements. Through cooperative efforts of industry and the Navy, a working-test exposure was installed in 1978 at Roosevelt Roads, Puerto Rico using piling treated with creosote containing the additive naphthalene in ranges of 10 to 40 percent. The piling cut-offs produced during this installation are being used for laboratory and field exposures to determine the preservative effectiveness of the added naphthalene.

OBJECTIVES

The objectives of this study are to determine the preservative effectiveness of various percentages of naphthalene-enriched creosote treatments exposed to *Limmoria tripunctata* attack in the laboratory and in a natural seawater environment; to determine if *Limmoria* attack is accelerated by exposure in the laboratory and to investigate if there are any seasonal differences in the rate of *Limmoria* attack in a natural environment where molluscan borers are also present.

MATERIALS AND METHODS

Three-inch discs from pile cut-offs were received at Battelle's New England Marine Facility - The William F. Clapp Laboratories in Duxbury, Massachusetts for laboratory exposure and at Battelle's Florida Marine Research Facility in Daytona Beach, Florida for field exposure. A total of 38 discs, nine treated with 10 percent naphthalene creosote, 10 with 28 percent naphthalene creosote, 10 with 30 percent naphthalene creosote, and nine with 40 percent naphthalene creosote were to be used.

Laboratory Exposures

Three discs from each treatment were cut into eight pie-shaped segments, the heartwood removed, and the resulting wedge coated with Koppers Bitumastic 300 M on all surfaces except the outside circumferal surface. The uncoated surface of these wedges represents the area normally exposed to *Limmoria* attack on pilings. A fourth disc from each treatment was also cut into eight segments but was not coated. These wedges have the area normally inside a piling exposed to *Limmoria* attack also.

Twelve coated and four uncoated wedges per treatment were exposed to active *Limmoria tripunctata* attack in flowing seawater tables in the laboratory on October 31, 1979. An untreated soft pine coupon, measuring 73 mm x 103 mm x 18 mm, was added to each table to serve as a control. These samples composed Series 1.

The second series of samples was placed in laboratory water tables on March 24, 1980, during a normally heavy *Limmoria* migrating season (March-April). During preparation of the discs on October 9, 1979, two of the discs were spoiled. Since replacements were not received, the second set of exposures was not a complete replicate of the first set. Only the 10 percent and 40 percent naphthalene creosote discs were available for the second series. Preparation and method of exposure were the same as used in Series 1.

Field Exposures

The cross-section surfaces of 16 discs (four per treatment) were drilled with a 5/8" (16 mm) center hole, coated with Koppers

Bitumastic 300 M on the sawn surfaces, mounted on four galvanized steel rods, and submerged vertically in the natural seawater environment at the Florida Marine Research Facility at Daytona Beach, Florida. Each rod held one disc from each treatment simulating an in-place piling. Four rods and discs for Series 1 were installed September 17, 1979; the remaining discs received were installed on two rods with three discs each for Series 2 on March 27, 1980. The order of arrangement of discs on the rods is shown in Table 1.

RESULTS AND DISCUSSION

Series 1 - Laboratory Exposures

Inspections for *Limmoria* attack were performed monthly. The results of these inspections are shown in Table 2.

All treated wedges remained free of *Limmoria tripunctata* for over two months. By the end of the three-month exposure period, *Limmoria* had started tunneling into two of the coated 10 percent naphthalene creosote wedges. With the exception of one of the 20 percent naphthalene creosote coated wedges which had one tunnel after three and four months exposure, and two tunnels at five months, none of the other wedges except the 10 percent coated wedges were attacked by *Limmoria* until after six months of exposure.

The wedges with the 10 percent naphthalene were the first to be attacked by *Limmoria* but this early attack did not continue to increase at the same rate as the attack in the other treatments.

The rate of increase in the *Limmoria* attack from the eight month inspection to the twelfth month inspection was 3 percent for the 10 percent additive, 61 percent for the 20 percent additive, 39 percent for the 30 percent additive and 47 percent for the 40 percent additive.

At the inspection after one year of exposure to active *Limmoria* attack in the laboratory, the coated wedges from the 10 percent naphthalene additive showed the greatest resistance to attack by *Limmoria tripunctata* with a mean of 27 tunnels per wedge (Table 3). Four of the coated wedges were still without any *Limmoria* attack at the end of one year of exposure.

TABLE 1. ORDER OF DISC PLACEMENT ON ROD, FOR
FIELD EXPOSURES OF DAYTONA BEACH, FLORIDA

1	2	Set		5	6
		3	4		
10%	20%	30%	40%	30%	20%
20%	30%	40%	10%	20%	30%
30%	40%	10%	20%	20%	20%
40%	10%	20%	30%		

Sets 1-4 installed September, 1979.

Sets 5-6 installed March 27, 1980.

TABLE 2. NUMBER OF *Limnoria* TUNNELS IN WEDGES
ON LABORATORY EXPOSURE - SERIES 1

Treatment	Sample Number	1	2	3	4	5	6	7	8	9	10	11	12
10% Naphthalene Creosote (Coated)	1			9	11	14	27	27	27	27	27	27	40
	2						1	1	1	1	1	1	2
	3												
	4								12	19	19	21	31
	5												
	6												
	7			67	70	70	70	70	70	70	70	70	73
	8					2	2	2	2	2	12	53	105
	9												
	10						4	4	4	4	4	4	12
	11										7	13	42
	12										1	4	18
10% (Uncoated)	1												
	2			13	13	15	15	15	15	15	15	15	23
	3			15	15	15	15	15	15	15	15	15	48
	4			7	7	7	12	12	12	12	13	17	51
20% Naphthalene Creosote (Coated)	1												2
	2												
	3												
	4											1	1
	5						1	1	1	1	5	17	44
	6												45
	7												7
	8										9	18	36
	9						3	3	4	7	11	33	90
	10			1	1	2	2	2	2	3	29	48	110
	11										10	26	71
	12										3	19	35
20% (Uncoated)	1										5	18	67
	2					4	4	4	4	4	4	7	120
	3										3	9	88
	4										1	8	37
30% Naphthalene Creosote (Coated)	1								2	4	28	100	200
	2										1	7	28
	3						5	5	5	5	6	9	47
	4								1	3	14	38	70
	5						4	4	6	32	100	205	290
	6						19	19	22	86	100	130	185
	7						2	2	16	60	140	200	300
	8								2	31	40	110	140
	9						1	1	1	1	2	12	35
	10						12	13	20	130	190	300	360
	11						8	8	32	92	130	210	275
	12									2	11	30	72

TABLE 2. (continued)

Treatment	Sample Number	1	2	3	4	5	6	7	8	9	10	11	12
30% (Uncoated)	1								11	65	100	210	250
	2						30	30	110	300	320	350	400
	3						38	38	60	160	200	300	390
	4						8	14	35	65	110	160	190
40% Naphthalene Creosote (Coated)	1												4
	2										3	18	26
	3												6
	4										1	7	22
	5										4	12	14
	6												3
	7										4	14	32
	8										2	5	10
	9										33	75	140
	10										26	80	130
	11									7	50	200	300
	12						9	9	21	90	110	200	320
40% Naphthalene Creosote (Uncoated)	1					6	40	45	70	300	325	350	450
	2						10	12	50	140	150	210	260
	3						12	17	60	125	200	300	475
	4						19	39	90	280	285	300	380

TABLE 3. MEAN NUMBER OF *Limnoria* TUNNELS IN LABORATORY WEDGES AFTER 5 TO 12 MONTHS OF EXPOSURE

Series No.		Months							
		5	6	7	8	9	10	11	12
1	10% Coated	7.2	8.7	8.7	9.7	10.3	11.8	16.1	27
	10% Uncoated	9.3	9.3	9.3	9.3	9.3	10.8	11.8	30.5
	20% Coated	0.2	0.5	0.5	0.6	0.9	5.6	13.5	36.6
	20% Uncoated	1.0	1.0	1.0	1.0	1.0	3.3	10.5	78.0
	30% Coated	0.0	4.3	4.3	8.9	37.2	63.5	112.3	166.8
	30% Uncoated	0.0	19.0	20.5	54	147.5	182.5	255	307.5
	40% Coated	0.0	0.0	0.0	1.8	8.1	19.4	50.9	83.9
	40% Uncoated	1.5	20.3	28.3	67.5	211.3	240	290	391.3
2									
	10% Coated	1.7	5.5	5.5					
	10% Uncoated	0	0	.25					
	40% Coated	0	0	2.4					
	40% Uncoated	17	52	83					

The amount of attack in the 20 percent naphthalene additive wedges was very similar to that in the 10 percent wedges with a mean of 37 *Limmoria* tunnels per wedge after one year of exposure. Two of these wedges were free of any attack.

The treatment which showed the least resistance to *Limmoria tripunctata* under laboratory conditions was the 30 percent additive. These wedges all showed *Limmoria* tunnels present with a mean of 167 tunnels per wedge.

Wedges with a 40 percent naphthalene additive, with a mean of 84 tunnels per wedge, stood up better than the 30 percent additive but not as well as the 10 percent and 20 percent.

Variance in the size of the piling cut-offs and resulting wedges is shown in Table 4. Taking this size difference into consideration, the ratio of numbers of *Limmoria* tunnels per square centimeter of exposed surface of coated wedges in the laboratory was 10 percent = 0.29, 20 percent = 0.34, 30 percent = 1.58, 40 percent = 1.30.

Series 2 - Laboratory Exposures

Complete replicate samples of the four treatments exposed in October, 1979 were not available. Series 2, therefore consists of 12 coated wedges and four uncoated wedges of the 10 percent and 40 percent treatments only. Results of the monthly inspections are shown in Table 5.

After six months of exposure, the results of these inspections are similar to those of Series 1 at six months. Four of the 10 percent coated wedges have been attacked by *Limmoria*; none of the 40 percent coated wedges and all of the 40 percent uncoated wedges show attack.

Series 1 - Field Exposures

At the sixth-month inspection of the discs on exposure at Daytona Beach, Florida, a few *Limmoria* had started tunneling in one of the 20 percent naphthalene creosote and one of the 40 percent naphthalene creosote piling cut-offs (Table 6).

TABLE 4. AREA OF SURFACE EXPOSED TO *Limnoria tripunctata*
OF SERIES 1 COATED WEDGES IN SQUARE CENTIMETERS

Wedges	10%	20%	30%	40%
1	105	115	114	74
2	119	125	112	82
3	121	104	118	88
4	130	67	108	65
5	113	117	102	63
6	106	122	104	103
7	114	105	117	86
8	124	132	108	72
9	80	99	104	103
10	125	122	128	106
11	96	113	100	79
12	<u>135</u>	<u>102</u>	<u>106</u>	<u>111</u>
Totals	1,368	1,323	1,321	1,032

TABLE 5. NUMBER OF *Limnoria* TUNNELS IN WEDGES
ON LABORATORY EXPOSURE - Series 2

Treatment	Sample Number	1	2	3	4	5	6
10% Naphthalene Creosote (Coated)	1					14	20
	2					2	11
	3						
	4					2	3
	5					2	2
	6						
	7						
	8						
	9						
	10						
	11						
	12						
10% (Uncoated)	1						
	2						
	3						
	4						
40% Naphthalene Creosote (Coated)	1						
	2						
	3						
	4						
	5						
	6						
	7						
	8						
	9						
	10						
	11						
	12						
40% (Uncoated)	1				6	9	18
	2					26	70
	3					19	40
	4			2	13	14	80

TABLE 6. NUMBER OF *Limmoria* TUNNELS IN DISCS ON FIELD EXPOSURE

Set	Months Exposed	Treatment			
		10%	20%	30%	40%
1	6	0	0	0	0
	12	100	600	800	1300
2	6	0	10	0	0
	12	1000	1300	400	1000
3	6	0	0	0	6
	12	4000	5500	200	1000
4	6	0	0	0	0
	12	500	600	350	1300
5	6	-	1800	2000	-
			3000		
6	6	-	Lost	4000	-
			Lost		

When inspected again after 12 months of exposure, all discs showed trace to moderate attack by *Limmoria* as well as a trace attack by Pholadidae (Tables 6 and 7).

The *Limmoria* attack in the 10 percent and 20 percent discs showed great variation. The number of tunnels in the 10 percent additive discs ranged from 100 in Set 1 to 4000 in Set 3. In the 20 percent additive discs, the range was 600 tunnels in Sets 1 and 4 to 5500 tunnels in Set 3. The variation among discs was not as great in the other two treatments. The range in the 30 percent discs was 200 tunnels in Set 3 to 800 tunnels in Set 1. Very little difference in attack was observed in the 40 percent discs. Sets 2 and 3 had 1000 *Limmoria* tunnels and Sets 1 and 4 had 1300 *Limmoria* tunnels.

Most of the discs had one to six specimens of the boring mollusc, Pholadidae, at the 12-month inspection. This is not a very heavy pholad attack but does indicate the treatments are not a deterrent to this molluscan borer.

The 30 percent naphthalene creosote discs showed the greatest resistance to *Limmoria* attack under field conditions with a mean of 438 tunnels per disc. The 20 percent disc was most severely attacked, with a mean of 2000 *Limmoria* tunnels per disc. The mean number of tunnels in the 10 percent additive was 1600, and there were 1150 tunnels in the 40 percent additive.

Series 2 - Field Exposures

Four 20 percent and two 30 percent naphthalene enriched creosoted pile cut-offs were submerged at Daytona Beach, Florida in March, 1980. At the six-month inspection, two of the 20 percent treatments from Set 6 were missing. The remaining discs all showed light to moderate *Limmoria* attack.

The two 30 percent discs were more severely attacked in six months of exposure than the 30 percent discs in Series 1 which had been on exposure for 12 months (Table 6). These two discs showed a mean of 3000 tunnels per disc which is greater than any of the discs which were in Series 1.

TABLE 7. NUMBER OF SPECIMENS OF PHOLADIDAE
IN DISCS ON FIELD EXPOSURE

Set*	Treatments			
	10%	20%	30%	40%
1	0	1	1	1
2	2	2	1	3
3	4	6	3	3
4	2	3	2	2
5	-	2	0	-
6	-	-	2	-

* Sets 1-4 on exposure for 12 months, Sets 5-6 exposed for 6 months.

The field samples were heavily fouled with barnacles and other organisms both at the six-month and twelve-month inspection periods. At the March 27, 1980 inspection, all discs were covered with very heavy settlement of barnacles with traces of Hydroid, Amphipods, and Annelida. In September, 1980, the heavy fouling was dominated by barnacles with traces of Hydroid, Amphipods, Ascidians, Crassostrea and filamentous bryozoan. As much fouling as possible was removed at the time of the inspections.

Laboratory samples were inspected monthly and all fouling removed. No barnacles became attached to these samples. Very little fouling except for a slime film and a few Ascidians was present on these exposures.

Comparison of Field and Laboratory Exposures

After 12 months of exposure to *Limmoria tripunctata* in the laboratory and in the field, the creosoted piling cut-offs with naphthalene added were all attacked by gribbles. Field and laboratory exposures have indicated different results after one year. The 30 percent naphthalene cut-offs were the most successful in the field and were the least successful in the laboratory (Table 8).

In the field exposures, the order of best protection was 30, 40, 10, and 20 percent, respectively.

In the laboratory exposures, the order of best protection was 10, 20, 40, and 30 percent, respectively.

The 30 percent discs submerged in March, 1980 show a much heavier *Limmoria* attack than any of the discs submerged for one year.

Uncoated Wedges

The number of *Limmoria* tunnels in the uncoated wedges was not included in the overall assessment of effectiveness of the four treatments.

These wedges generally showed heavier attack than coated wedges. By not coating the cut surface with Bitumastic 300 M, surfaces not exposed

TABLE 8. MEAN NUMBER OF MARINE BORERS IN DISCS
AND RECONSTITUTED DISCS
(Discs submerged 12 months.)

	10%	20%	30%	40%
Mean # of <i>Limmoria</i> Tunnels	1600	2000	438	1150
Mean # of Pholadidae	2	3	1.75	2.25
<u>Coated Wedges Exposed 12 Months</u>				
Mean # of <i>Limmoria</i> Tunnels	33	37	167	84
<u>Uncoated Wedges Exposed 12 Months</u>				
Mean # of <i>Limmoria</i> Tunnels	31	78	308	392
Mean # of <i>Limmoria</i> Tunnels in Reconstituted Disc (8 Wedges = 1 Disc) (Coated)	264	295	1341	675
Total # of <i>Limmoria</i> Tunnels in Reconstituted Disc (8 Wedges = 1 Disc) (Uncoated)	244	624	2460	3130

to *Limmoria* attack in actual pilings were attacked by *Limmoria*. The destruction was increased by borers first entering the cut surface areas before they started burrowing into the edges of the outside piling surface area (Table 8).

Water Temperature

Water temperatures in the laboratory exposures ranged from a low of 10°C to a high of 32.5°C (Table 9). Both of these extremes were in December, 1979. During the period from October to June, the laboratory sea water passes through a heat exchanger in order to maintain temperatures that will support the breeding of *Limmoria* all year.

The average temperature of the laboratory sea water during the period these discs were exposed to active *Limmoria* attack was 19.3°C.

The discs submerged at the Florida Marine Research Facility in Daytona Beach, Florida were subjected to a low of 11°C and a high of 28°C (Table 10). The average water temperature at the field site was 21.6°C during the period from September, 1979 to September, 1980.

TABLE 9. LABORATORY WATER TEMPERATURES °C FROM
NOVEMBER, 1979 THROUGH OCTOBER, 1980

	High	Low	Average
<u>1979</u>			
November	22.5	15.5	19.9
December	32.5	10.0	18.4
<u>1980</u>			
January	22.5	16.5	19.1
February	22.5	14.0	18.6
March	27.0	15.5	19.3
April	21.5	18.5	19.9
May	22.5	18.0	20.9
June	20.0	18.0	19.3
July	21.0	17.5	18.9
August	22.5	18.5	20.1
September	21.5	14.0	18.0
October	20.5	15.5	18.8

Temperature readings based on daily 9:00 AM readings from Taylor Temperature Recorder.

TABLE 10. DAYTONA BEACH WATER TEMPERATURES °C
FROM SEPTEMBER, 1979 THROUGH SEPTEMBER, 1980

	High	Low	Average
<u>1979</u>			
September	27	25	25.4
October	27	22.5	24.8
November	24	18	21.3
December	20	15.5	17.8
<u>1980</u>			
January	17.5	12	15.4
February	14	11	12.5
March	20	11	18.2
April	22	19	20.3
May	24.5	20.5	21.7
June	27.5	24	25.6
July	28	24.5	26.3
August	27	24	26
September	27.5	24	26.1

OFFICE OF NAVAL RESEARCH
NAVAL BIOLOGY PROJECT
STANDARD DISTRIBUTION LIST

Number of Copies

(12)

Administrator
Defense Technical Information Center
Cameron Station
Alexandria, VA 22314

(6)

Director
Naval Research Laboratory
Attn: Technical Information Division
Code 2627
Washington, DC 20375

(3)

Office of Naval Research
Naval Biology Project
Code 443
800 N. Quincy Street
Arlington, VA 22217

One copy to each of the following:

Office of Naval Research
Code 200
800 N. Quincy Street
Arlington, VA 22217

Dr. A.L. Salfkosky
Scientific Advisor, Commandant of
Marine Corp (Code RD-1)
Washington, DC 20380

Office of Naval Research Eastern/
Central Regional Office
Building 114, Section D
666 Summer Street
Boston, MA 02210

Assistant Commander for Research &
Development
Code 03
Naval Facilities Engineering Command
200 Stovall Street
Alexandria, VA 22332

Office of Naval Research Branch
Office
536 South Clark Street
Chicago, IL 60605

Biological Sciences Staff
Code 112B
Naval Facilities Engineering Command
200 Stovall Street
Alexandria, VA 22332

Office of Naval Research Western
Regional Office
1030 East Green Street
Pasadena, CA 91106

Scientific Library
Naval Biosciences Laboratory
Naval Supply Center
Oakland, CA 94625

Technical Library
U.S. Army Natick Laboratories
Natick, MA 01760

Enclosure (3)

STANDARD DISTRIBUTION LIST (Cont'd)

Commander
Army Research Office
Research Triangle Park, NC 27709

Technical Advisory Division
National Marine Fisheries Service
Department of Commerce

Head, Disease Vector Control Section
BUMED (MED-31412)
Department of the Navy
Washington, DC 20372

Matthew Stevenson
National Academy of Sciences
Room JH 538
2101 Constitution Avenue
Washington, DC 20418

Alexander, Dr. Martin
Department of Agronomy
Cornell University
Ithaca, New York 14850
NR 205-032
N00014-78-C-004

Colwell, Dr. Rita R.
Department of Microbiology
University of Maryland
College Park, Maryland 20742
NR 133-081
N00014-75-C-0340

DePalma, Mr. John
National Space Technology Lab
Building 1105, Room C-316
NSTL Station, Mississippi 38522
NR 205-006
N0001479WR90115

Fahlstrom, Mr. G.B.
Osmose Wood Preserving Company
980 Ellicot Street
Buffalo, New York 14209
NR 205-036
N00014-80-G-0033

Belmore, C. Irene
Battelle Columbus Laboratories
William F. Clapp Laboratories, Inc.
Washington Street
Duxbury, Massachusetts 02332
NR 205-034
N00014-79-C-0667

Commanding Officer
Naval Medical Research & Development
Command, Code 47
National Naval Medical Center
Bethesda, MD 20014

Commandant, DAT
U.S. Coast Guard
400 Seventh Street, SW
Washington, DC 20511

Commandant, DAS
U.S. Coast Guard Research & Development
Center
Avery Point
Groton, CT 06340

Commander Naval Oceanography Command
NSTL Station
Bay St. Louis, MS 39529

Officer in Charge
Navy Disease Vector Ecology & Control
Center
Naval Air Station
Alameda, CA 94501

Officer in Charge
Navy Disease Vector Ecology & Control
Center
Naval Air Station
Jacksonville, FL 32212

David W. Taylor Naval Ship Research &
Development Center
Code 286
Annapolis, MD 21402

David W. Taylor Naval Ship Research &
Development Center
Code 2856
Annapolis, MD 21402

Mitchell, Dr. Ralph
Harvard University
Division of Engineering and Applied
Physics
Cambridge, Massachusetts 02138
NR 205-002
N00014-76-C-0262

STANDARD DISTRIBUTION LIST (Cont'd)

Romanovsky, Dr. V.
Centre de Recherches et d'Etudes
Oceanographiques
73-77, rue de Sevres
92100 Boulogne, FRANCE
NR 205-016
N00014-78-M-0034

Vedros, Dr. Neylan A.
Scientific Director
Naval Biosciences Laboratory
Naval Supply Center
Oakland, California 94625
NR 205-001
N00014-75-C-0774

Guard, Dr. Harold E.
Naval Biosciences Laboratory
Naval Supply Center
Oakland, California 94625

Laughlin, Dr. Roy
Naval Biosciences Laboratory
Naval Supply Center
Oakland, California 94625

EN

DA

FILE

2

DT